

REMARKS

At the outset, the Applicants wish to thank Patent Examiner Johannes Mondt for the many courtesies extended to the undersigned attorney during the Personal Interview on March 24, 2004, at the U.S. Patent and Trademark Office. The substance of this Personal Interview is set forth in the Examiner Interview Summary, and in this Amendment.

The Patent Examiner has rejected claim 5, under 35 U.S.C. 112, first paragraph for lack of enablement.

During the Personal Interview, there was a discussion of the wording "the balance being argon". It was agreed that revising this wording in claim 5 to read "the balance substantially being argon", would overcome this formal rejection under 35 U.S.C. 112. Hence claim 5 was thusly amended. The Specification was amended in the paragraph bridging pages 4 to 5 to support the terminology in claim 5.

Withdrawal of this ground of rejection under 35 U.S.C. 112 is respectfully requested.

The Patent Examiner has rejected claims 2 and 4-6, under 35 U.S.C. 103, as being unpatentable over the following references in various combinations:

Ikari et al in view of *Yamamoto et al, Kim, Tamatsuka, Holder, and Kono.*

The present invention is directed to preventing the

formation of an oxide layer coating the inner surface of voids. Such voids are caused by agglomerated vacancy defects. The oxidation of the inner surface by supersaturated oxygen is prevented by the presence of hydrogen in the voids. This implies that a considerable amount of hydrogen is necessary to achieve the desired effect. To the contrary, the present invention is based upon the discovery that the partial pressure of hydrogen should not exceed more than 3 mbar in order to avoid the formation of hydrogen related cavities.

The Patent Examiner has argued that argon which is purified according to the newly cited reference Yamamoto et al. usually contains up to 1 ppm hydrogen as an impurity. However, this reference refers to the fact that "the concentration of each H₂, N₂, CO₂, O₂ and CH₄ is 1 ppm or less". There is no disclosure what the concentration of H₂ actually is. The 1 ppm value has to be considered as a worst case scenario since the Yamamoto et al. teaching is directed to the production of highly pure argon. In addition, the reference teaches "since the differences between argon and the impurities in boiling point are large, it is relatively easy to separate these impurities from argon in the distillation column" (Please see column 8, lines 40-46). The process as disclosed Yamamoto et al. intends to reduce the hydrogen content in argon to traces which are as small as possible. Hence the process is directed to reduce the amount of hydrogen as effectively as possible in order to avoid any action

due to the presence of hydrogen.

The present invention, on the other hand, uses the action of hydrogen in order to prevent the formation of an oxide film which covers the inner wall of the voids. Even if we assume that 1 ppm hydrogen is present in the argon and the total pressure is 60 Torr, the partial pressure of the hydrogen would be as small as 0.000079992 mbar which is a marginal value if compared to the claimed amount of 3 mbar or less. This amount of hydrogen in Yamamoto will not generate the desired result according to the present invention.

Therefore, in order to clearly distinguish the present invention from Yamamoto *et al.* reference and from the other prior art, claim 2 has been amended to recite that a hydrogen partial pressure of less than 3 mbar substantially prevents oxygen from oxidizing internal surfaces of the voids. Support for this is found on page 4 of the present Specification.

As discussed above, and more particularly the Yamamoto U.S. Patent No. 6,123,909 in column 2, in lines 3 to 39 discloses that the argon purification process is a process for purifying argon to obtain a high-purity argon from argon gas containing at least nitrogen, carbon monoxide, oxygen, and methane, comprising:

a first step of adding air or oxygen to the argon gas to oxidize the carbon contained in the monoxide into carbon dioxide in the presence of a catalyst;

a second step of adding hydrogen into the argon gas obtained in the first step and reacting the contained oxygen with the hydrogen into water in the presence of a catalyst;

a third step of removing the carbon dioxide and the water from the argon gas obtained in the second step by use of an absorbent; and

a fourth step of cooling the argon gas obtained in the third step, introducing the argon thus cooled into a distillation column, performing distillation by use of a reflux containing argon as a main component to remove nitrogen, hydrogen, methane, thereby recovering high purity argon gas.

It is preferable, in the fourth step, that the argon gas obtained in the third step be cooled to liquefy most part of argon and simultaneously to separate and remove hydrogen-condensed argon gas, and then, the liquefied argon be introduced into the distillation column.

The distillation portion of the distillation column preferably consists of an upper stage portion, a middle stage portion, and a lower stage portion. The liquefied argon is introduced into a space between the upper stage portion and the

middle stage portion. The argon gas containing nitrogen and hydrogen condensed therein is withdrawn from a top portion of the distillation column. The liquefied argon containing methane condensed therein is withdrawn from a bottom portion of the distillation column. The high purity argon gas is recovered from the space between the middle stage portion and the lower stage portion.

Yamamoto in column 8 in lines 33 to 47 discloses according to the argon purification process of the present invention, of the impurities, first CO, whose boiling point (boiling point: -192°C) is very close to that of argon (boiling point: -186°C), is oxidized into CO₂, and then O₂ (boiling point: -183°C), whose boiling point is very close to that of argon, is converted into water. Then, both components are removed by the cooling unit and the water and carbon-dioxide removing unit. Thereafter, argon (deoxoargon) containing N₂ (boiling point: -196°), H₂ (boiling point: -253°) and CH₄ (boiling point: -162°C) as impurities is introduced into the distillation column, to remove N₂, H₂ and CH₄. Since the differences between argon and the impurities in boiling point are large, it is relatively easy to separate these impurities from argon in the distillation column.

For all these reasons, *Yamamoto* fails to teach or suggest the claimed invention.

In addition, the *Ikari U.S. Patent No. 6,548,886* in column 14 in lines 17 to 55 discloses for the purpose of repressing the

occurrence of minute pits on the surface of the silicon wafer without varying the electrical characteristics of the wafer or inducing the occurrence of such defects as stacking faults during the course of heat-treating devices, it is necessary that the nitrogen content in the silicon wafer be not less than 1.0×10^{13} atoms/cm³ and not more than 1.0×10^{16} atoms/cm³. Then, by using the silicon wafer of this description as a substrate wafer and depositing a silicon single crystal layer on the surface of the substrate wafer by the epitaxial method, the occurrence of minute defects and void defects in the epitaxial layer or near the interface between the epitaxial layer and the substrate wafer mentioned above is repressed and, at the same time, the silicon semiconductor substrate to be produced is enabled to have suitable crystal defects in the wafer interior and enjoy a fortified gettering ability. If the nitrogen content in the silicon wafer is less than 1.0×10^{13} atoms/cm³, the occurrence of minute pits on the surface of the wafer will not be repressed. If it exceeds 1.0×10^{16} atoms/cm³, the silicon semiconductor substrate of fine quality will not be obtained by depositing the epitaxial layer because of the variation of such electrical characteristics as carrier life time and resistivity and the occurrence of stacking faults. Incidentally, the nitrogen content in the wafer can be determined by using SIMS.

The silicon semiconductor substrate of the second mode of *Ikari* according to the second aspect is a silicon semiconductor

substrate obtained by using as a substrate wafer a silicon wafer having an oxygen content of not less than 1.0×10^{17} atoms/cm³ and depositing a silicon single crystal layer on the surface of the substrate wafer by the epitaxial method. This wafer is characterized by containing at least in a region reaching a depth of 1 μm from the interface between the substrate wafer mentioned above and the silicon single crystal layer deposited thereon by the epitaxial method crystal defects measuring not less than 0.1 μm as reduced in diameter at a density of not more than 5×10^4 pieces/cm³.

Thus *Ikari* fails to teach or to suggest pulling a silicon single crystal under a hydrogen partial pressure of less than 3 mbar thus substantially preventing oxygen from oxidizing internal surfaces of the voids, as claimed.

Holder U.S. Patent No. 6,039,801 in column 2 in lines 27 to 55 discloses a process for reducing the amount of hypostoichiometric silicon dioxide in a crystal pulling apparatus through continuous oxidation of silicon compounds produced during production of silicon ingots. The process comprises continuously injecting an argon gas stream into the apparatus above the hot zone during ingot growth such that the argon stream flows downwardly within the apparatus through the hot zone and into an exhaust tunnel and continuously injecting an oxygen containing gas through an inlet in the exhaust tunnel in the apparatus at a position downstream from the hot zone relative to the argon gas

flow to continuously oxidize silicon monoxide, silicon vapor and hypostoichiometric silicon dioxide produced during ingot growth.

Holder is further directed to a process for reducing the amount of hypostoichiometric silicon dioxide in a crystal pulling apparatus through continuous oxidation of silicon compounds produced during production of silicon ingots. The process comprises continuously injecting an argon gas stream into the apparatus above the hot zone during ingot growth such that the argon stream flows downwardly within the apparatus through the hot zone and into an exhaust tunnel and continuously injecting an oxygen containing gas through an inlet in the exhaust tunnel in the apparatus at a position downstream from the hot zone relative to the argon gas flow to continuously oxidize silicon monoxide, silicon vapor and hypostoichiometric silicon dioxide produced during ingot growth without allowing sufficient oxygen to enter the hot zone and cause perfect structure loss in the growing ingot.

Continuously injecting oxygen as in *Holder* is contrary to the claimed invention of pulling the silicon single crystal under a hydrogen partial pressure of less than 3 mbar thus substantially preventing oxygen from oxidizing internal surfaces of the voids, as claimed.

The *Kono Japanese Patent* discloses a manufacturing method for a silicon on insulator SOI substrate having a diameter equal to or larger than the large caliber of a single crystal wafer.

Polycrystalline silicon is fused by using a quartz crucible having a large caliber, and a polycrystalline silicon rod is obtained by cooling. The rod is sliced and subjected to mirror polishing, and a retaining substrate 5 is formed. When the crystal orientation of a single crystal silicon rod grown by a CZ method is <111>, the rod is worked into a regular hexagonal pole, sliced, and subjected to mirror polishing, and a single crystal silicon wafer 7 is formed. The wafer 7 is subjected to oxidation treatment, and stuck on the retaining substrate 5 without generating a gap, and an SOI substrate is constituted. The upper surface of the wafer 7 is polished to obtain a specified thickness. Glass, ceramics, etc., may be used as a retaining substrate. By sticking a single crystal silicon wafer 8, which is worked into an equilateral triangle, on the periphery of the single crystal silicon wafer 7, the area of the retaining substrate 5 can be effectively used.

The *Kono* disclosure of subjecting the silicon single crystal wafer to an oxidation treatment fails to teach or to suggest pulling a silicon single crystal under a hydrogen partial pressure of less than 3 mbar thus substantially preventing oxygen from oxidizing internal surfaces of the voids, as claimed.

The *Tamatsuka U.S. Patent No. 6,191,009* in column 1 in lines 8 to 15 discloses a method for producing a silicon single crystal wafer in high productivity wherein the size of crystal defect inside the crystal, called grown-in defect, is decreased by

doping nitrogen when pulling a silicon single crystal by a Czochralski method and the gettering ability is improved by subjecting the wafer to heat treatment.

Thus *Tamatsuka* fails to teach or to suggest pulling a silicon single crystal under a hydrogen partial pressure of less than 3 mbar thus substantially preventing oxygen from oxidizing internal surfaces of the voids, as claimed.

The *Kim* U.S. Patent No. 5,942,032 in column 3 in lines 5 to 20 discloses a heat shield assembly and method for a crystal puller that facilitates the growth of low defect single crystals. The provision of such a heat shield assembly and method inhibits agglomeration of defects in the crystal growth process. The provision of such a heat assembly and method facilitates high throughput in the crystal puller. The provision of such a heat shield assembly and method is capable of operating in confined space with a crystal puller. The provision of such a heat shield assembly can be raised and lowered using the existing pulling mechanism of the crystal puller.

Thus *Kim* fails to teach or to suggest pulling a silicon single crystal under a hydrogen partial pressure of less than 3 mbar thus substantially preventing oxygen from oxidizing internal surfaces of the voids, as claimed.

In summary, claims 2 and 5 have been amended, and claims 2 and 4 to 6 are pending. In view of these amendments, it is firmly believed that the present invention, and all the claims

are patentable under 35 U.S.C. 103 over all the prior art applied by the Patent Examiner. A prompt notification of allowability is respectfully requested.

Respectfully submitted,

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Enc: 1) Petition for 3 Month Extension of Time Large Entity
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